

# Efficacy of surface landmark palpation for identification of the cricoid cartilage in obstetric patients: A prospective observational study

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## Abstract

**Background and Aims:** Rapid sequence induction, with the application of cricoid pressure is an accepted practice during induction of general anesthesia in pregnant patients to prevent pulmonary aspiration. We found no prior studies assessing the accuracy of locating the cricoid cartilage by professional caregivers, and therefore conducted an observational study to assess the ability of different caregivers – anesthesia consultants, anesthesia residents, respiratory therapists (RTs), and nurses, in the obstetric care unit, to correctly identify the cricoid cartilage of parturients. We hypothesized that anesthesia consultants would be most accurate.

**Material and Methods:** Institutional REB approval was obtained, as was written informed consent from all participants in the study. The subjects were made up of thirty healthy obstetric patients scheduled for elective cesarean delivery. Their cricoid cartilages were assessed by 53 caregivers (assessors). Localization of the cricoid cartilage by assessors was considered accurate if it was within 5 mm of the sonographically identified mark. The difficulty in localization was reported on a VAS scale and the time taken for localization was recorded.

**Results:** Data from 30 subjects and 53 assessors (13 anesthesia consultants, 12 residents, 13 RTs, and 15 nurses) performing a total of 60 evaluations (some assessors evaluated 2 subjects) were analyzed. About 60% of RTs, 53% of anesthesia residents, 40% of anesthesia consultants, and 13% of nurses correctly identified the cricoid cartilage. No differences in caregivers' perception of difficulty were found, but RTs were the quickest at identification ( $P < 0.001$  vs anesthesia consultants;  $P = 0.002$  vs residents;  $P = 0.071$  vs nurses).

**Conclusion:** RTs were the most successful and accurate in identifying the cricoid cartilage of parturients among the different groups of professional caregivers.

**Keywords:** Airway, cricoid cartilage, obstetric, ultrasound

## Introduction

Although controversial, rapid sequence induction with the application of cricoid pressure remains the standard of practice for cesarean deliveries performed under general anesthesia, especially in North America.<sup>[1]</sup> Recent guidelines by the

Obstetric Anesthetists Association and Difficult Airway Society for management of difficult tracheal intubation recommend the application of cricoid pressure in parturients as well.<sup>[2]</sup> At our academic tertiary care obstetric unit, anesthesia providers (both consultants and residents), as well as respiratory therapists (RTs), and nurses, may be requested to apply cricoid pressure during the induction of general anesthesia for a parturient. In our experience, it is not uncommon to find the application of cricoid pressure to be a

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hinderance to obtaining a view of the glottis and often require release of the pressure to allow successful intubation. We wondered if the cricoid cartilage was being correctly identified.

A literature search did not identify any studies assessing providers' accuracy in identifying the cricoid cartilage. We did find studies that evaluated identification of the cricothyroid membrane by anesthesia providers which revealed disappointing success rates. Of note, it has been speculated that if most anesthesia providers cannot identify the cricothyroid membrane, it is likely that many will also not be able to locate the cricoid cartilage.<sup>[3]</sup>

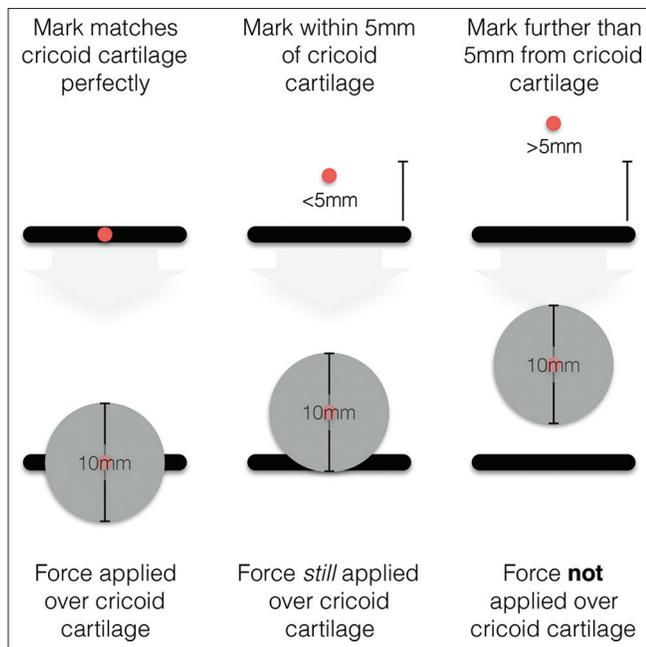
We conducted this study to assess the success rates of caregivers from different disciplines at correctly identifying the cricoid cartilage in an obstetric population using palpation. We hypothesized that consultant anesthesiologists would be the most successful at identifying the cricoid cartilage and that misidentification would most likely occur in obese patients.

## Material and Methods

The Western University Research Ethics Board approved this prospective observational study (HSREB File Number 107035) in November 2015. The study was registered in the Clinical Trials.gov database before the first patient was enrolled (NCT02416219). Written informed consent was obtained from all participants. Women with a singleton pregnancy scheduled for elective cesarean delivery of a term infant were recruited to have their neck palpated; they were

considered the study "subjects.". Exclusion criteria for the subjects were age <18, subject refusal, history of severe pre-eclampsia, significant concern about maternal or fetal welfare, and nonscheduled cesarean delivery. The demographics collected for the subjects include age, height, weight, body mass index (BMI), neck circumference, gestational age, and American Society of Anesthesiology (ASA) classification. Healthcare providers who are involved in the airway management of parturients at our institution include members from four caregiver groups: Anesthesia consultants, residents, RTs, and registered nurses (RNs). Members from each of these groups were recruited and considered to be the "assessors" in the study. They were asked to identify the cricoid cartilage of the subjects using palpation. Information collected from the assessors was their occupation and years of experience. For residents, their postgraduate training level was also collected.

Participants (assessors and subjects) were recruited based on convenience. The study subjects were asked to lie supine with one pillow under their head in the perioperative holding area bed with their neck in the sniffing position in order to reflect the position they might take prior to intubation. One of the investigators with experience in ultrasonographic identification of the cricoid cartilage scanned each subject's neck to identify the true location of the cricoid cartilage. This investigator did not palpate the necks of any subjects. Using a SonoSite MicroMaxx linear array probe (SonoSite Inc. Brothell, WA, USA), the middle of the cricoid cartilage was identified and marked using an invisible ink (Invisible Ink Spy Pen with Built in UV Light Magic Marker: China). Each



**Figure 1:** Illustration of the force distribution over the cross-sectional area when applying the pressure

**Table 1: Demographic Characteristics of the Patients and Assessors**

Characteristic	Mean ± SD or n (%)
<b>Patients (n=30)</b>	
Age-yr	32.4 ± 6.0
Weight-kg	88.7 ± 21.4
Height-cm	163 ± 6.6
Body mass index-kg/m <sup>2</sup>	33.5 ± 7.5
Neck circumference-cm	37.3 ± 3.3
Gestational age-weeks	38.9 ± 0.5
<b>American Society of Anesthesiologists Classification</b>	
2	25 (83)
3	5 (17)
<b>Assessors (n=60)</b>	
<b>Caregiver Group</b>	
	Years of clinical experience
Consultant anesthesiologist	16.1 ± 7.2
Resident in anesthesia	3.5 ± 3.6
Respiratory therapist	17.6 ± 9.6
Registered nurse	12.5 ± 10.6

SD, standard deviation.

subject's neck was palpated by two separate assessors, who were asked to draw a line where they thought cricoid pressure should be applied, again using the invisible ink. Assessors examined each subject's neck independently from each other. The subjects were asked to assume the same (sniffing) position for palpation as they did for the ultrasound. The investigator timed the duration of palpation from when the assessor made contact with the subject's neck, until their mark was made. Using UV light, the vertical distance between the assessor's mark, and the ultrasonographically-marked location of the cricoid cartilage, termed as "error," was measured in mm. If the error fell within 5 mm of the true location of the cricoid, the assessor was considered to have correctly identified the location where cricoid pressure should be applied and was termed as a "success." We chose this cutoff based on an appeal to physics and anatomy, as there are no published studies to use as a precedent. We started with the conservative estimate that an average human index finger is 10 mm in diameter. If the pen mark indicated the center-point where cricoid pressure would be applied that force would be distributed over the cross-sectional area of the finger being used to apply the pressure. It follows that a finger which is 10 mm in diameter would exert a pressure up to 5 mm above and below the center point over which the pressure is applied [Figure 1]. Following palpation, each assessor subjectively rated the difficulty of identifying the cricoid cartilage using a 10 cm visual analogue scale, with 0 indicating "very easy to identify" and 10 indicating "impossible to identify."

### Statistical analysis

No formal sample size calculation was performed because this was the first time this type of study has been performed in obstetric patients. A convenience sample of 30 subjects was chosen to be assessed by 53 assessors (13 anesthesia consultants, 12 residents, 13 RTs, and 15 nurses) performing 60 palpations. Each assessor was allowed to participate in the palpation of up to two separate subjects to get a total of 15 assessments in each category of assessors. Descriptive statistics were calculated for subject and assessor demographics. Number of successes in each of the four caregiver groups were tabulated and compared using the Chi-squared test.

Measurements of the cricoid cartilage location was clustered within subjects (each subject had two assessments). Because of this, the primary outcome (success in each of the four caregiver groups) was compared among groups by using a multilevel logistic regression model using the primary outcome as the dependent variable, the type of assessor (i.e., consultant, resident, RT, or RN) as a fixed effect, and the subject as a random effect. The consultant anesthesiologists were set as the base level for the model. Pairwise comparisons of odds ratios (OR) between types of assessors were made.

The mixed effect models and pair-wise comparisons were repeated using a linear multilevel model for average error in measurement distance, difficulty of marking, and time. For each of these models, the only regressors were the fixed effect for the type of assessor and the random effect for the subject. The correlation between the error and the difficulty in marking was assessed quantitatively (using linear regression) and graphically.  $P < 0.05$  was considered to be statistically significant. All analyses were performed in Stata version 14 (StataCorp LP, College Station, TX, USA).

## Results

Data from 30 subjects and 53 assessors (13 consultants, 12 residents, 13 RTs, and 15 nurses) performing a total of 60 palpations were analyzed. Table 1 shows the demographic characteristics of the subjects and assessors. There were 9 subjects with a BMI of  $\geq 35$ , and 5 subjects having a BMI of  $\geq 40$ .

The overall success rate for all palpations was 25/60, with RTs being the most successful, followed by anesthesia residents, consultants, and finally nurses [Table 2]. The mean VAS score for difficulty of identifying the subject's cricoid cartilage was assigned the highest value by anesthesia consultants, followed by RTs, residents, and nurses, who assigned the task the lowest score [Table 2]. There was a significant difference in success rates between nurses and RTs (OR = 0.08 for correct identification of the cricoid cartilage for nurses compared with RTs, 95% CI 0.01–0.7,  $P = 0.024$ ),

**Table 2: Palpation attempted by each caregiver**

Caregiver Group	Number of Successful Palpations n (%)	Difficulty (mm) mean $\pm$ SD	Error (mm) mean $\pm$ SD	Time (s) mean $\pm$ SD
Consultant Anesthesiologist	6/15 (40)	4.2 $\pm$ 2.3	8.1 $\pm$ 7.5	12.5 $\pm$ 4.9
Resident in Anesthesia	8/15 (53)	3.8 $\pm$ 1.3	7.5 $\pm$ 4.7	10 $\pm$ 3.8
Respiratory Therapist	9/15 (60)	3.9 $\pm$ 1.8	6.6 $\pm$ 5.5	7.8 $\pm$ 3.3
Registered Nurse	2/15 (13)	3.7 $\pm$ 2.1	16.1 $\pm$ 12.1	10.1 $\pm$ 5.2
	$\chi^2 P=0.048$	ANOVA $P=0.89$	$P=0.002$	$P=0.31$

Difficulty is the caregivers' subjective assessment of difficulty in identifying the cricoid cartilage. Error is the average distance from the assessor's mark to the sonographically identified location of the cricoid cartilage. Time is the time taken from the start of palpation until a mark is made by the caregiver.

and between nurses and residents (OR = 0.09 for nurses compared with residents, 95% CI 0.01–0.9,  $P = 0.042$ ). The average error between the marked and true location of the cricoid cartilage was the smallest in the RT group and largest in the nurse group [Table 2]. There was a significant difference in the average error when comparing nurses to consultants ( $P = 0.004$ ), nurses to residents ( $P = 0.002$ ), and nurses to respiratory therapists ( $P < 0.001$ ). Anesthesia consultants took the longest time to identify the cricoid cartilage, followed by nurses, residents, and RTs who completed the task quickest [Table 2].

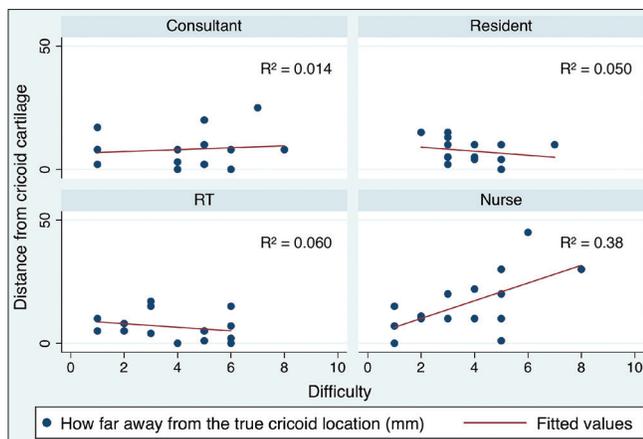
On linear regression analysis, BMI was not a predictor of distance from the cricoid cartilage ( $P = 0.66$ ), nor a predictor of difficulty in marking ( $P = 0.17$ ). Similarly, on linear regression analysis, neck circumference was not found to be a predictor of distance from the cricoid cartilage ( $P = 0.67$ ), nor a predictor of time taken for marking ( $P = 0.68$ ). Increasing neck circumference correlated with a higher difficulty of assessment on a VAS scale. For each centimeter increase in neck circumference, the difficulty score increased by 0.17 (95% CI 0.02–0.31,  $P = 0.025$ ). There was no correlation between the VAS score assigned by an assessor of any background, and their success rate in identifying the cricoid cartilage [Figure 2]. Of the marks which were more than 5 mm from the true location of the cricoid, 30 were placed above the true location, whereas only 5 of the incorrect marks were below. Table 3 shows pairwise ORs of successful recognition of cricoid cartilage (primary outcome).

## Discussion

In our study, the overall success rate for identification of the cricoid cartilage among all assessors was low, at only 42%. This finding, while disappointing, is not a surprise. Aslani

*et al.* had a similar finding while investigating physicians' ability to find the cricothyroid membrane (CTM) in female patients.<sup>[3]</sup> This is also comparable to the success rate You-Ten *et al.* published when investigating anesthesiologists' ability to identify the cricothyroid membrane in a population of obese and nonobese women in labor.<sup>[4]</sup> When only physician assessments of parturients are considered, the success rate at our institution remained poor at only 46%. However, this is better than the 24% and 35% success rate by physicians in locating the CTM in nonobese and obese women, respectively.

When comparing each caregiver group individually, RTs were the most successful at identifying the cricoid cartilage, followed by anesthesia residents, consultants, and finally nurses. Our definition of success is based on the assertion that application of pressure within 5 mm of the true location of the cricoid cartilage is both necessary and sufficient to correctly perform the cricoid pressure maneuver. There is no rigorous validation of this assertion, but our sentiment is echoed by Allen *et al.* who studied cricoid pressure in children. They found that cricoid pressure was applied a mean of 4.7–5.8 mm away from the true sonographic location of the cricoid cartilage, yet concluded that most of these distances would readily be covered by the breadth of the fingertip applying the pressure.<sup>[5]</sup> We looked at the average error in the distance marked from the true location of the cricoid in order to determine whether our cut off of 5 mm was artificially impacting the failure rate of certain cohorts. We found, however, that the average error in distance followed the same trend seen when our 5 mm cutoff was in place; RTs were closest to the true location of the cricoid cartilage, followed by anesthesia residents, then consultants. The marks placed by the nursing cohort were furthest from the true location of the cricoid cartilage and were significantly further away than the marks made by any of the other cohorts. The pattern seen may be a reflection of the practice pattern in our obstetric unit, and may not be generalizable. All cesarean sections performed at our institution are attended by an RT who assists the anesthesia team with airway management. As such, RTs are the most likely caregivers to apply cricoid pressure for parturients. The success of the RT cohort may, therefore, be a reflection of the frequency with which they are called upon to apply cricoid pressure. Similarly, it would be



**Figure 2:** There was no correlation between the visual analog scale score assigned by a participant of any background, and their success rate in identifying the cricoid cartilage

**Table 3: Pairwise Odds Ratios of Successful Recognition of Cricoid Cartilage**

	Odds ratio	95% CI	P
Resident vs Consultant	1.8	0.3 to 10.6	0.53
Respiratory Therapist vs. Consultant	2.1	0.3 to 12.2	0.43
Registered Nurse vs. Consultant	0.16	0.02 to 1.6	0.11

The odds ratio given is for the successful recognition of the first group compared to the second. Successful recognition of the cricoid cartilage was defined as within 5 mm of its true location. 95% CI, 95% confidence interval

less likely for obstetric nurses to be involved in the application of cricoid pressure, and this is reflected by their performance.

Although we expected that a high BMI would increase the difficulty of identifying the cricoid cartilage by palpation, and therefore reduce success rates, our data did not support this. Of note, neither obesity nor neck circumference were predictive of an increased distance of the palpated mark from the true location of the cricoid cartilage. These results are in keeping with the findings of Lamb *et al.*, who found no difference in the success rates of caregivers' ability to identify the CTM in obese compared with nonobese women.<sup>[6]</sup> We did find that increasing neck circumference was associated with caregivers' subjective assessment of an increased difficulty in palpation of the cricoid cartilage, though this did not translate into an increased time taken for palpation.

Our study is the first to assess caregivers' success rate at identifying the cricoid cartilage using palpation in obstetric patients undergoing elective cesarean section. We did not limit our population to physicians, but instead included all caregivers who might be called upon to apply cricoid pressure in the labor and delivery ward. This makes our findings more generalizable to the application of cricoid pressure by all-comers, instead of limiting it to physician caregivers. We used ultrasonographic identification of the cricoid cartilage by a single trained anesthesiologist, providing consistency in how the true location of the cricoid cartilage was identified.

Our study has several limitations which may impact our findings. No formal sample size calculation was performed due to the lack of published data in the area, and our sample size precludes us from drawing definitive conclusions from the data. In addition, participants were chosen according to convenience rather than randomly, which could have introduced bias, especially since each subject was not assessed by a representative from each caregiver group. Although there was a wide variation in the BMI of the subjects studied, the actual number of subjects with BMI >35 was limited, preventing us from drawing any firm conclusions on the impact of BMI. Another limitation of our analysis was that we did not account for the clustering of assessments within assessors. Although we accounted for the clustering of assessments within subjects, we did not account for the ability of each assessor to assess up to two subjects. This created clustering of assessments within assessors (i.e., there were crossed random effects). Since we had a limited sample size and since this research was preliminary, hypothesis-generating research, we elected to treat each assessor as being independent. Another limitation is that we made multiple pairwise comparisons without correcting for overall alpha error. Because our work is exploratory and hypothesis-generating, we accepted this as a limitation. The role

of ultrasound in identification of the cricoid cartilage is not well validated and our methodology is based on previous studies of the cricothyroid membrane, which is a different anatomical structure than the cricoid cartilage. Finally, we did not assess the clinical implications of incorrect localization of the cricoid cartilage.

Our study found all caregivers deficient in identifying the cricoid cartilage. Future research directions include a well-powered study to investigate the impact of ultrasound assessment on success rates for identifying the cricoid cartilage in the obstetric population, as well as a study specifically investigating the impact of coexisting diseases – such as pre-eclampsia and obesity – on successful identification of the cricoid cartilage.

## Conclusion

We found that anesthesia consultants, residents, respiratory therapists (RTs), and nurses had poor success with identification of the cricoid cartilage in parturients scheduled for elective cesarean section. Of all the care provider groups, RTs were the most successful at correctly identifying the cricoid cartilage. Our findings should encourage the development of training and competency maintenance programs to ensure that correct cricoid cartilage identification is obtained and maintained by caregivers.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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